Beam-beam compensation in an e^+e^- or eA collid

Parameter table

No. of FODO cells	N_{FODO}	50
Phase advance/cell (hor./vert.)	$\Delta\Phi_x/\Delta\Phi_y$	$79.7^\circ/89.0^\circ$
Chromaticity (hor./vert.)	ξ_x/ξ_y	$+2/+2$
β-function at IP and elens	β_x/β_y	0.19 m, 0.26 m
No. of protons/bunch	N_p	$4 \cdot 10^{11}$
rms beam size at IP and elens	σ_x/σ_y	$101\,\mu$m$/50.5\,\mu$m
Lorentz factor	γ	19560
damping times	$\tau_x/\tau_y/\tau_z$	1740/1740/870 turns

Ideal phase advance between IP and e-lens: $m \cdot \pi$, achieved by rotation matrices

Before:

IP and electron lens on opposite sides of the ring; 25 FODO cells (with sextupoles) in-between

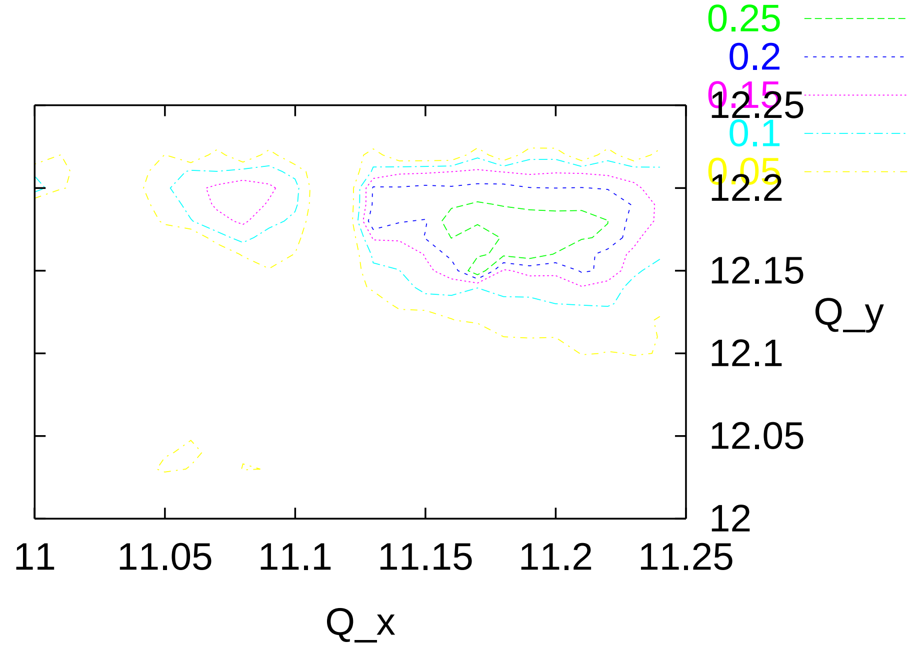
Ideal (achromatic) IR telescopes

Now: Chromatic IR telescopes

$$
\begin{aligned}
M_{\text{telescope}} &= \begin{pmatrix} \sqrt{\dfrac{\beta^*}{\beta_{\text{arc}}}}\cos\phi & \sqrt{\beta^*\beta_{\text{arc}}}\sin\phi \\ -\dfrac{1}{\sqrt{\beta^*\beta_{\text{arc}}}}\sin\phi & \sqrt{\dfrac{\beta_{\text{arc}}}{\beta^*}}\cos\phi \end{pmatrix} \\
\phi &= \xi_{\text{telescope}} \cdot \frac{\Delta p}{p} \\
\xi_{\text{telescope}} &= -2.5
\end{aligned}
$$

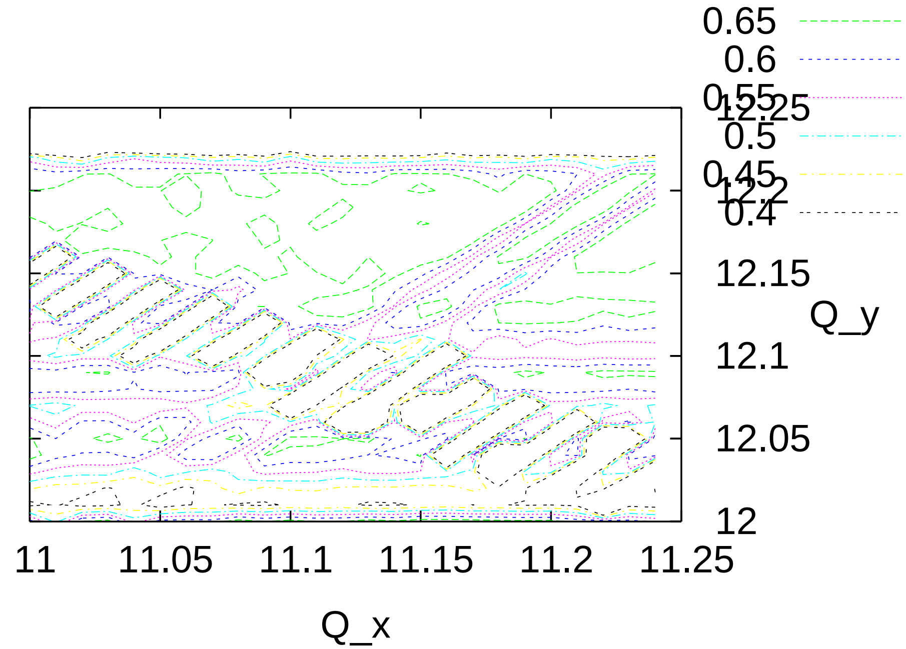
This additional chromaticity (4 telescopes, resulting in -10 units) has to be compensated by stronger sextupoles.
With these stronger sextupoles, beam-beam compensation completely fails if the electron lens is located on the opposite side of the ring (25 FODO cells away).
Moving it closer to the IP (10 FODO cells only) helps (next slides).

Tune scan without beam-beam compensation



At most 25 percent of expected (geometric) luminosity.

Tune scan with ideal beam-beam compensation



65 percent luminosity, rather insensitive to working point besides low-order resonances.